

PROPOSED BACKGROUND SELENIUM VALUES FOR GROUNDWATER AT THE HOMESTAKE MINING COMPANY NPL SITE, NEW MEXICO

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BLUEWATER VALLEY DOWNSTREAM ALLIANCE

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OVERVIEW

- General summary
- Data sources, assumptions, approach
- Results for alluvial aquifer, Chinle Mixing Zones, and Chinle Non-Mixing Zones
- Comparison of current and proposed Se baseline values
- Recommendations

GENERAL SUMMARY

- Groundwater protection standards (GWPS) are intended to represent groundwater quality that existed before mining and milling began
- Samples used for current GWPS include many samples that reflect mining influence
- If those samples are excluded, proposed GWPS are lower (more protective of human health); also considered wider temporal range than 1994-2005
- Current GWPS also include Mo, SO₄, Cl, TDS, NO₃, V, Th-230, Ra-226+228; still need to be re-evaluated using a similar approach

DATA SOURCES

- Water quality data used: Homestake database (Access database GRANTS.mdb) for alluvial and Chinle aquifers
- Wells used here for the different aquifers were identified as background using Arcadis (2019), Table 3
- More recent (1997-2019) and older data (1945-1996) in separate files in the Access database were combined by aquifer

ASSUMPTIONS

- Homestake data accurately reflect laboratory results; rejected data are excluded
- Aquifer and well designations are correct as provided
- Background water quality should represent natural conditions absent uranium mining effects.¹ Water quality data showing *consistent* concentration increases or decreases over time is an indication of mine-influenced water and should not be used
- Data from wells in identified alluvial contaminant plumes for a given time period should not be used, but results from before concentrations changed can be used
- Increases in different constituents may occur at different times because of their relative mobility, so evaluated separately; U and Se are not conservative but SO₄ may be – especially in the alluvial aquifer
 - Selenite sorbs more strongly to iron oxides/hydroxides than selenate. Higher pH, more oxygenated groundwater, and competition with other anions (bicarb more than sulfate) favors selenium mobility. Little to no information on Se or U speciation. Arcadis 2018: Se more mobile than U in alluvial aquifer.

1 ...uranium concentrations used in the background analyses completed for the site in 2004 have not been affected by up-gradient mining, and the background levels for uranium are considered representative of local natural conditions... (Homestake, 2015, p. 1-2; emphasis in original)

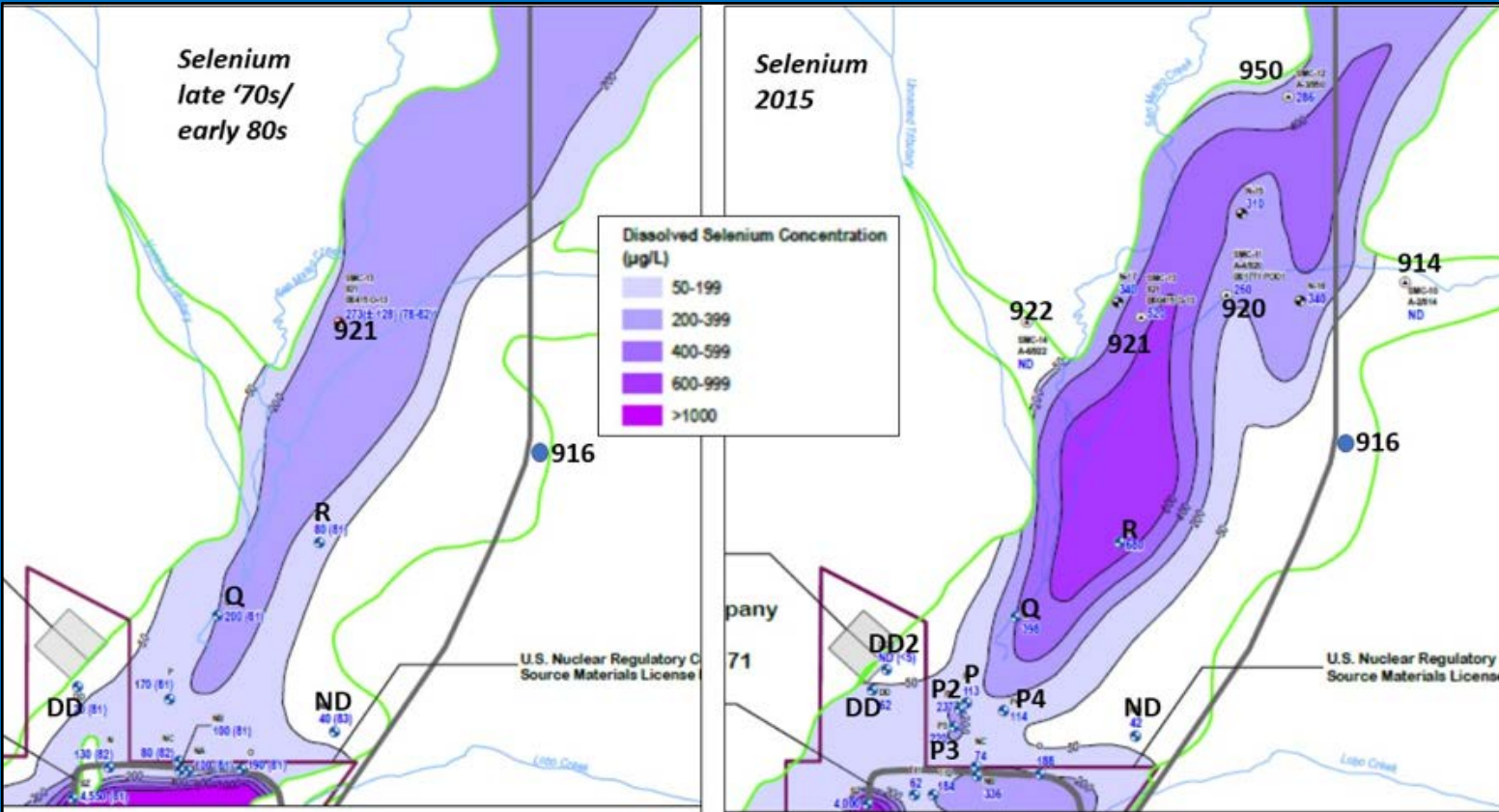
EPA 2009 STATISTICAL ANALYSIS GROUNDWATER DATA

- High quality background data is the single most important key to a successful statistical groundwater monitoring program, especially for detection monitoring.
- A key implication of the independent and identically distributed assumption [i.i.d.] is that a series of sample measurements should be stationary over time (i.e., stable in mean level and variance). Data that are trending upward or downward violate this assumption since the mean level is changing.

APPROACH

- Plot Se concentrations vs time for all aquifers
- Evaluate sources, pathways, plumes for different time periods
- Exclude data showing consistent concentration changes over time, in plumes (= mining influence), affected by remediation, unexplained spikes
- Use 95th percentile of remaining data to calculate non-mining-influenced baseline Se values for Homestake site groundwater

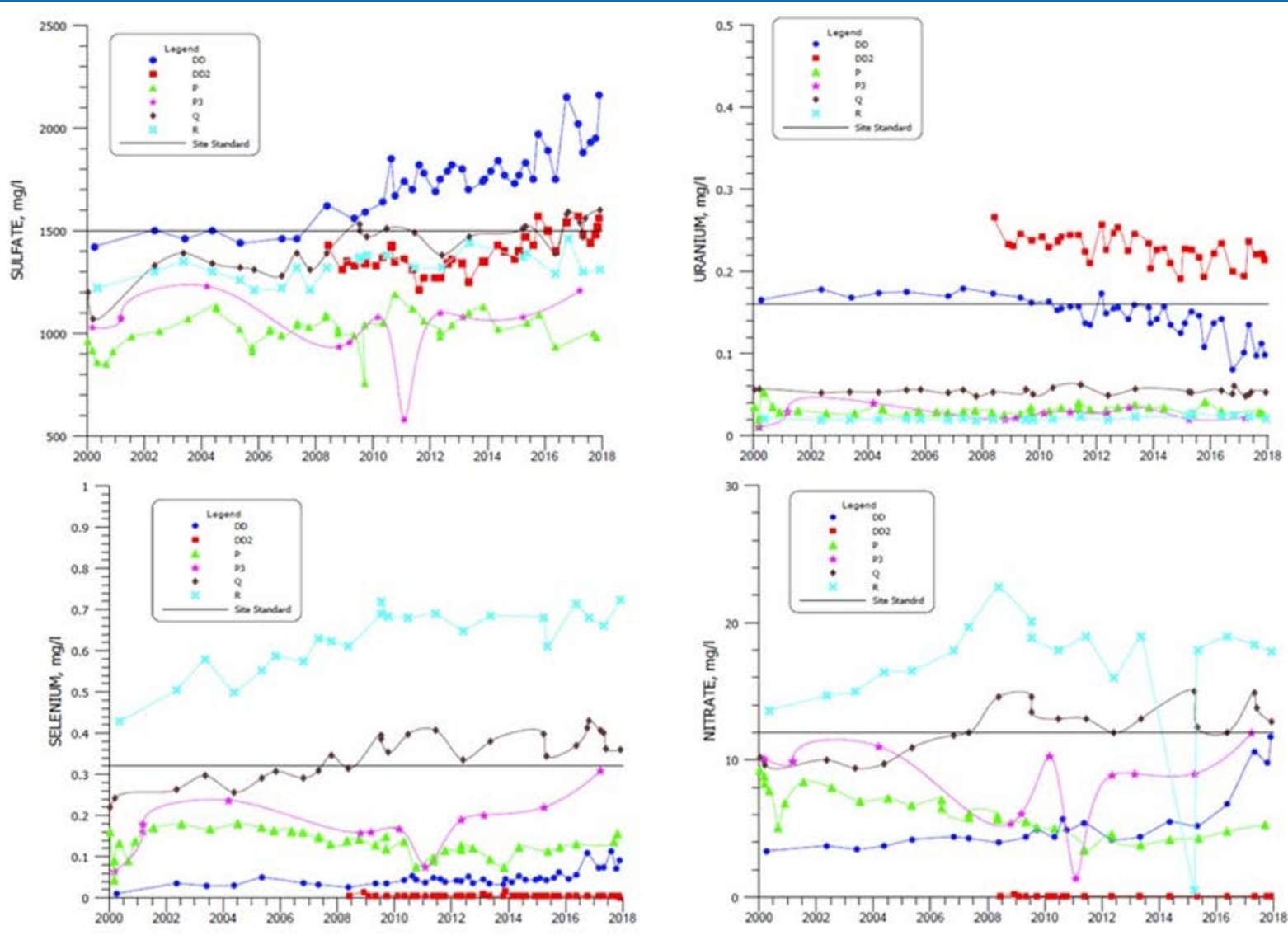
ALLUVIAL AQUIFER: PLUMES AND FLOW PATHS



- Se higher on the western side of aquifer upgradient of LTP
- Plume concentrations have increased markedly from late 1970s/early 1980 to present

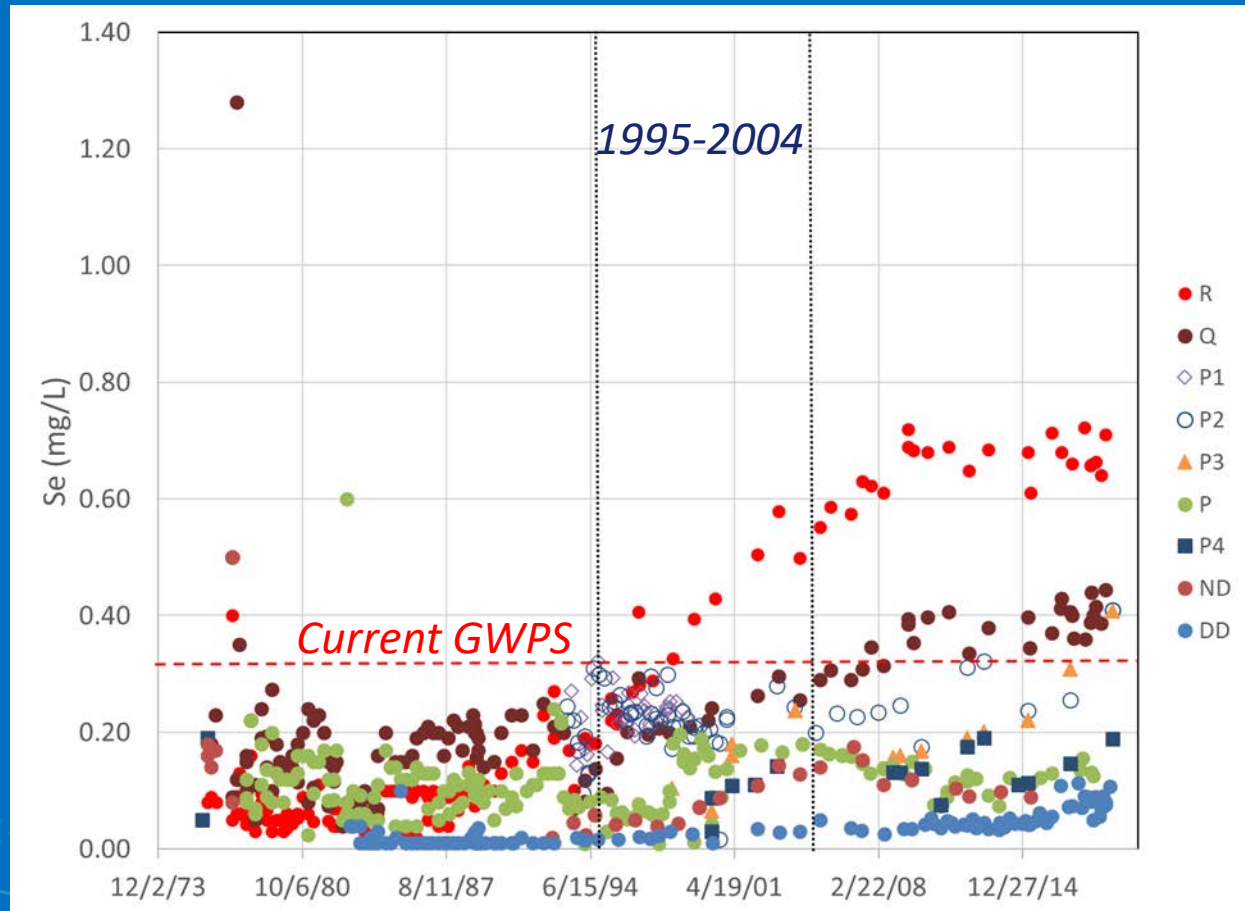
Source: Modified from Weston Solutions, 2018, Figures A4-17 & A4-18
(approximate location of well 916 taken from Fig. A4-28)

CHANGING CONCENTRATIONS OVER TIME IN WELL DD



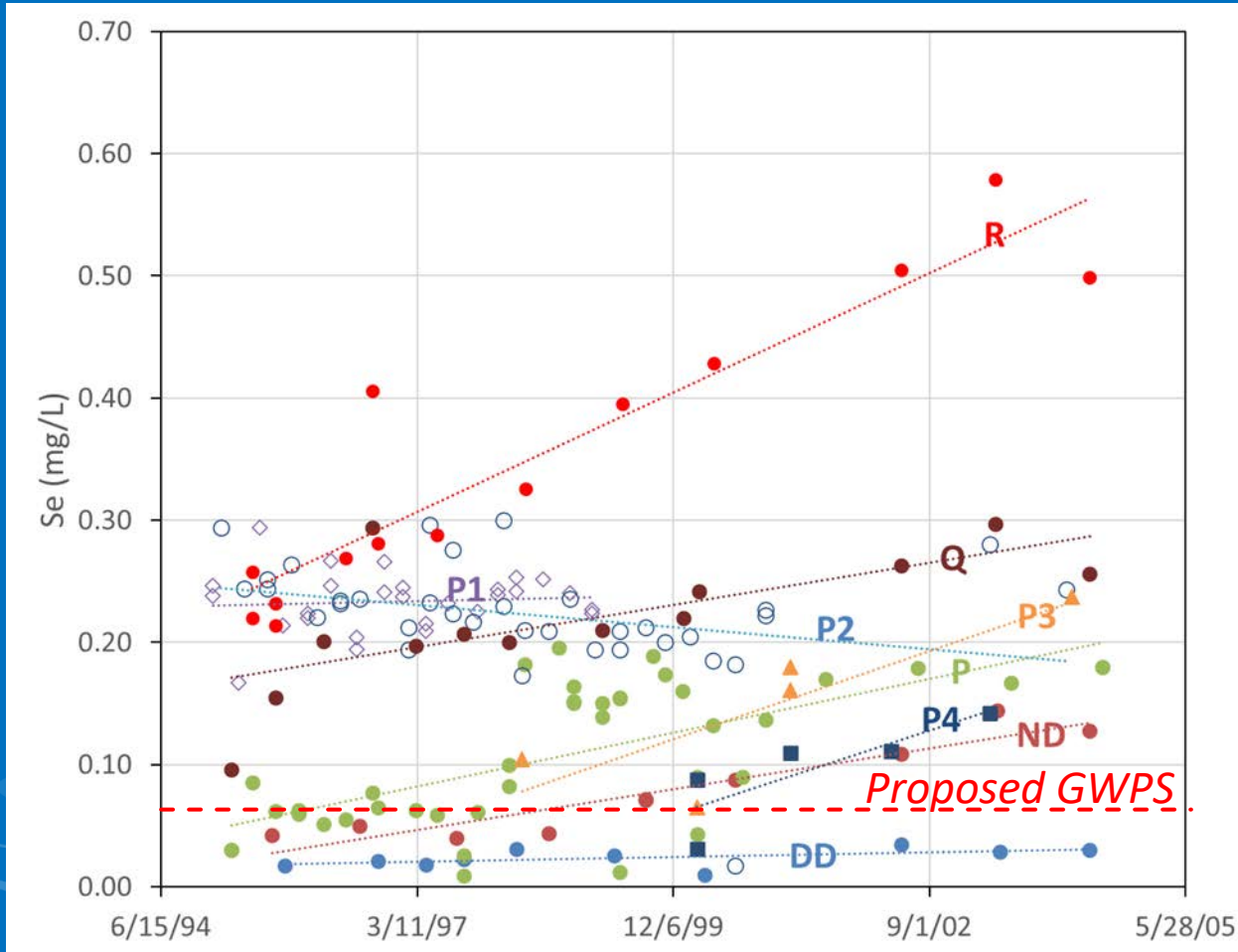
- Increasing SO_4 and NO_3 concentrations in DD since ~2010 suggest that the plume from the north has reached this area recently: increasing Se and decreasing U concentrations
- U is either natural or from another mining source but Se likely related to upgradient sources

CURRENT ALLUVIAL GWPS



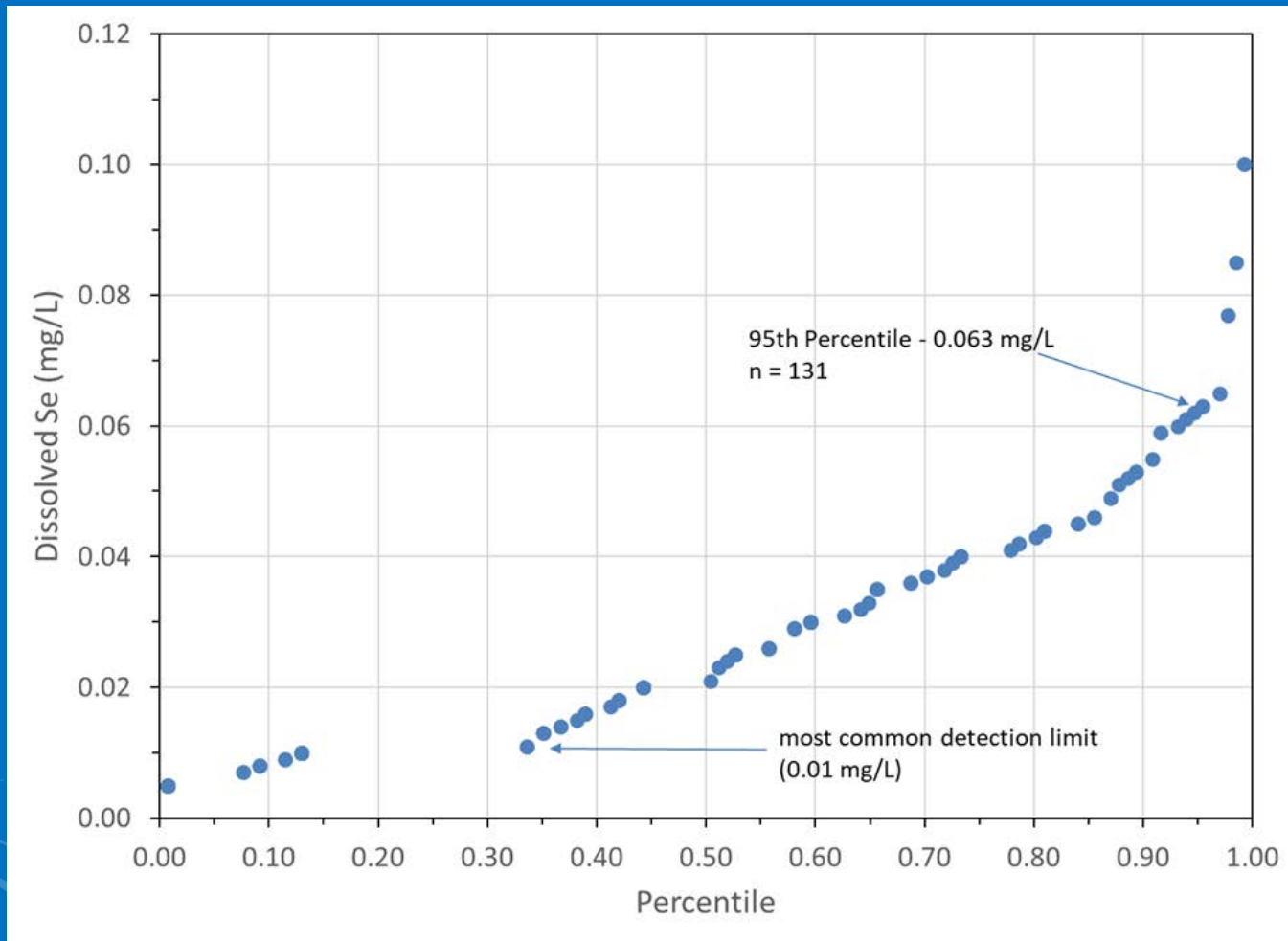
- Current GWPS used DD, ND, P, P1, P2, P3, P4, Q, and R

PROPOSED ALLUVIAL GWPS



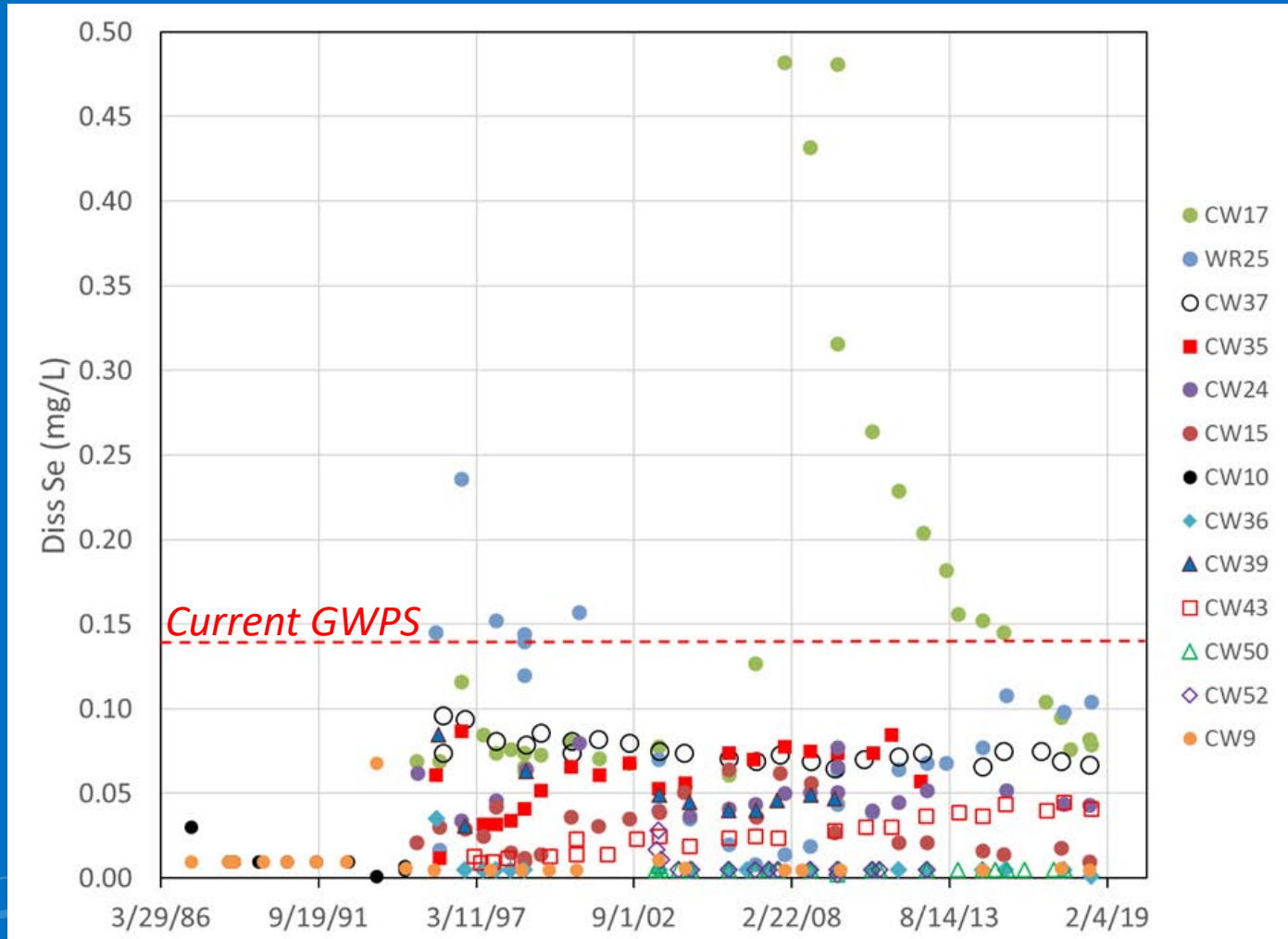
- Proposed GWPS excludes Q and R (erratic w/ no seasonal pattern), P1 & P2 (similar to Q, R – known to be affected), P3 no stable values
- Uses P (95-97), DD (81-2014), ND (83-98), 916 (94-2005)
- Well 916 only far upgradient well with information on total depth and screened interval and not affected by upgradient mines

STATISTICAL ANALYSIS – PROPOSED GWPS



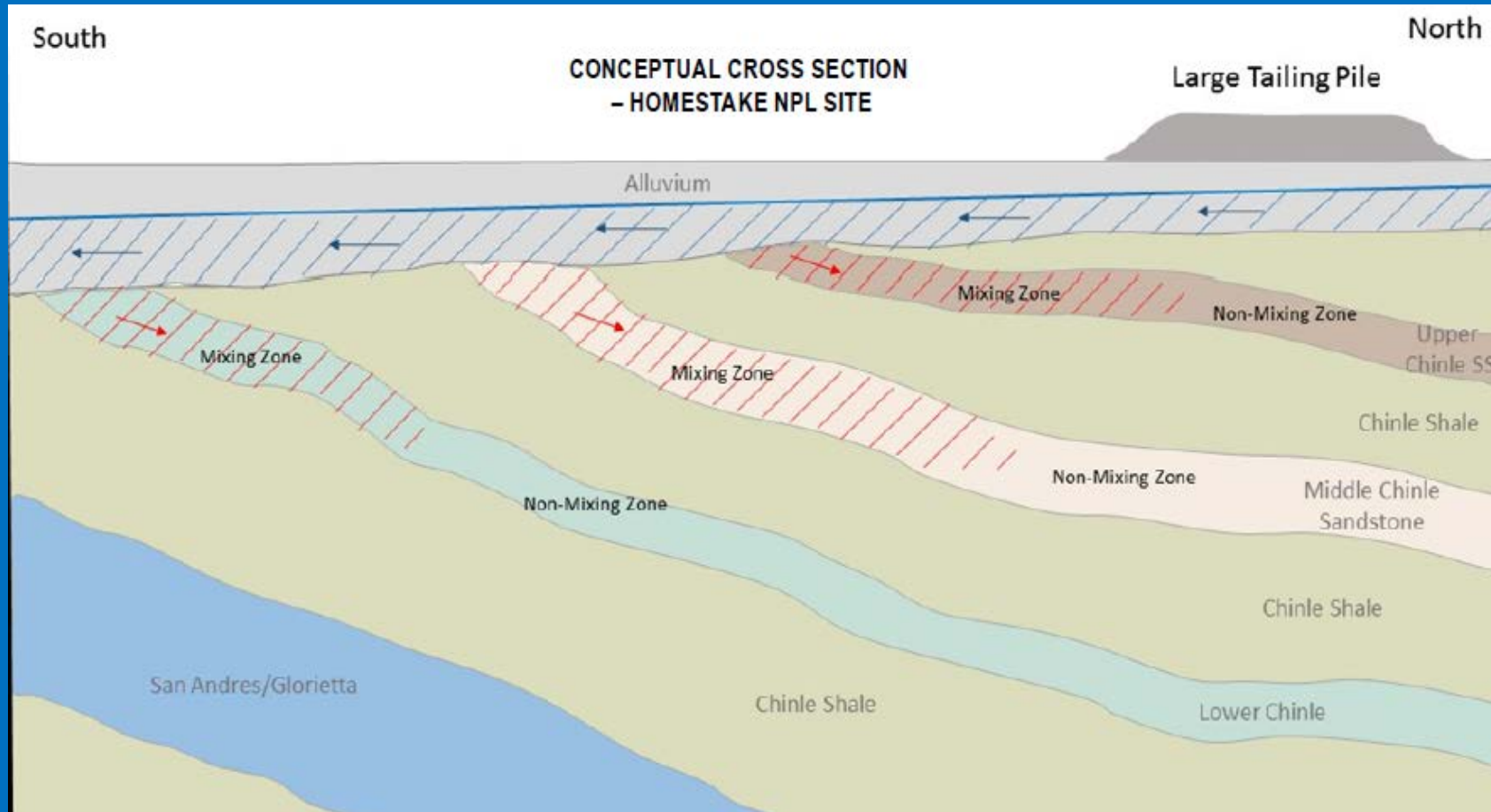
- Only 9.2% of values were below detection, so replaced with $\frac{1}{2}$ the detection limit
- Values at low end don't affect 95th percentile
- Proposed alluvial GWPS = 0.063 mg/L Se

CHINLE MIXING ZONES: ALL WELLS USED FOR CURRENT GWPS



- Chinle mixing zone exists because of contamination from previously saturated alluvial aquifer
- Separate Chinle Mixing Zone aquifers do not have current GWPS – just one for all mixing zones
- Some clear mining influence in selected wells

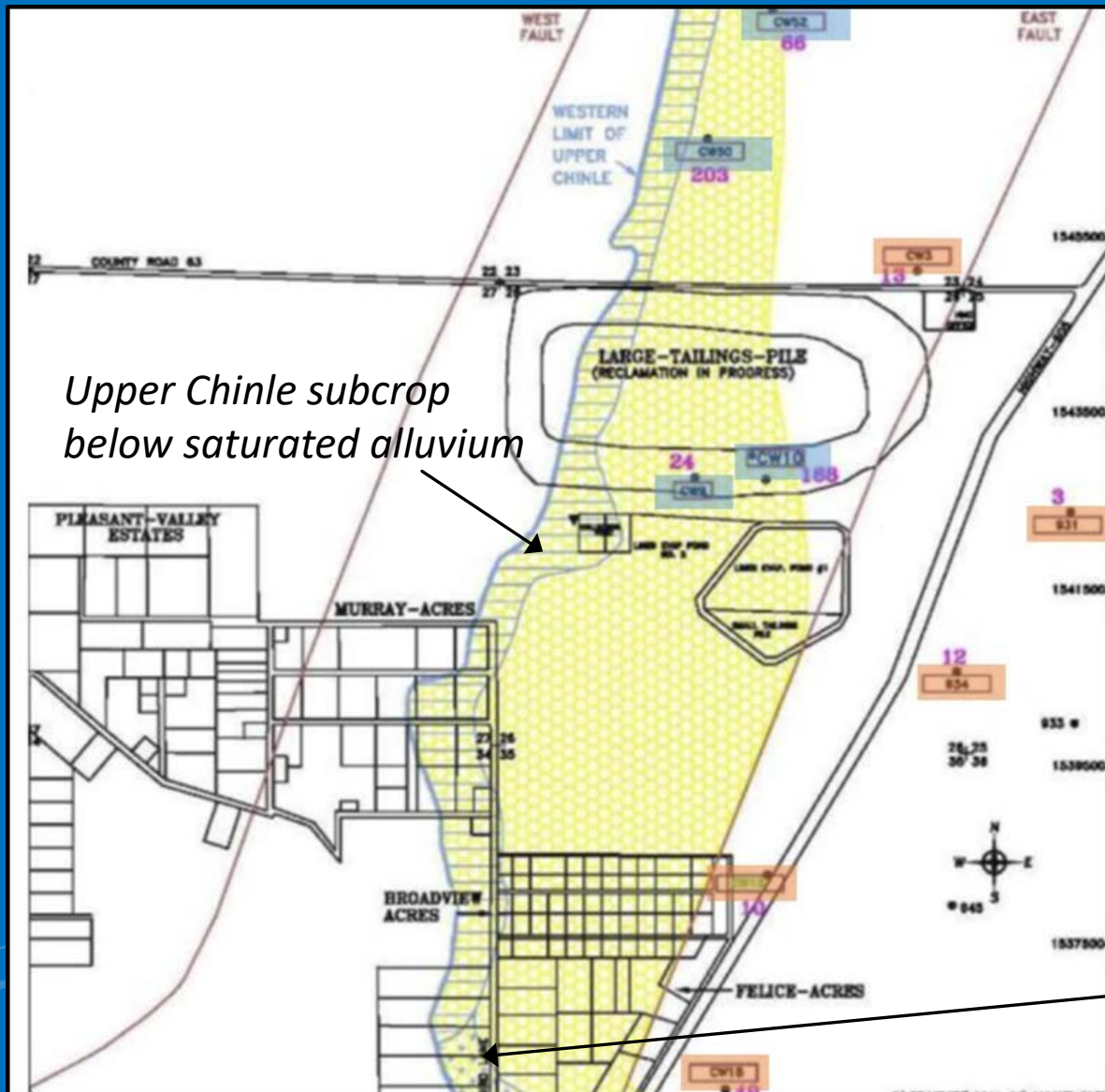
EPA CONCEPTUAL MODEL: MINE-IMPACTED ALLUVIUM CONTAMINATES THE CHINLE



“An important component of the conceptual site groundwater model is the downward vertical movement of mine discharge water recharge from the alluvium to underlying and tilted bedrock formations at subcrop areas.”

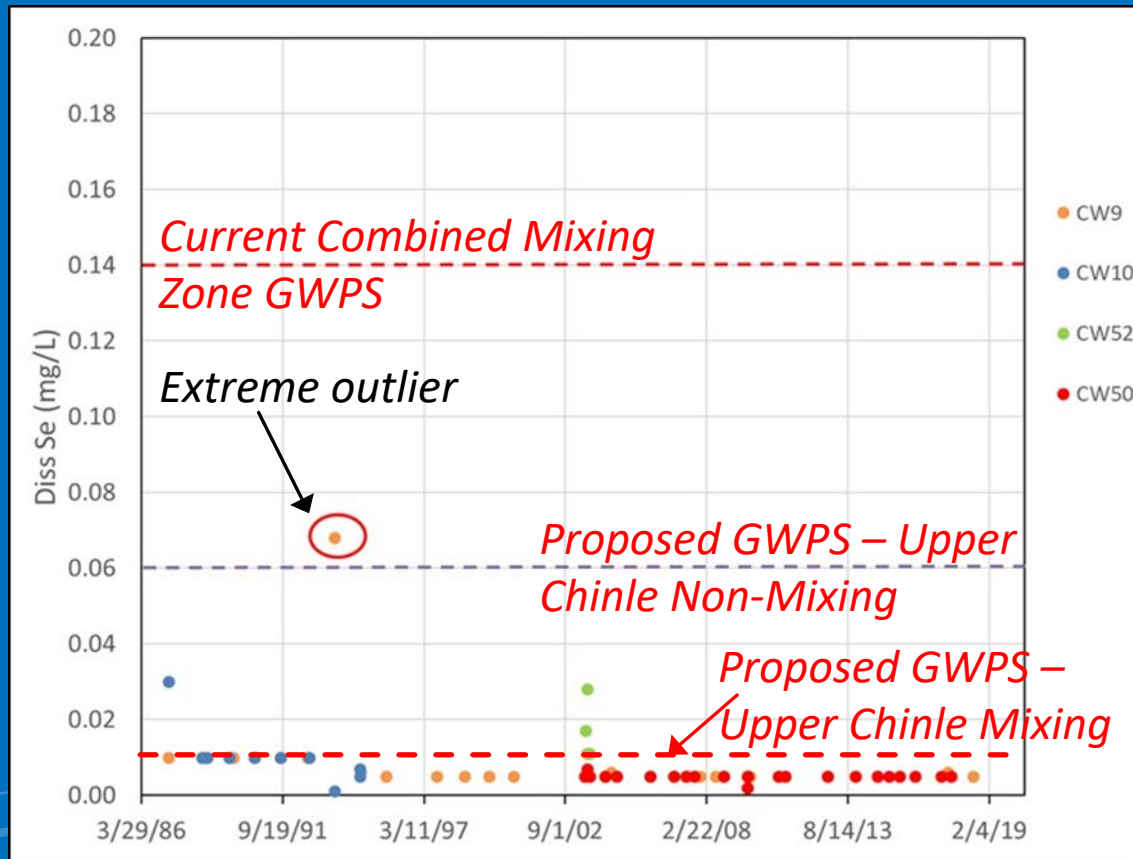
Weston Solutions, 2018, p. ES-6

UPPER CHINLE BACKGROUND WELLS



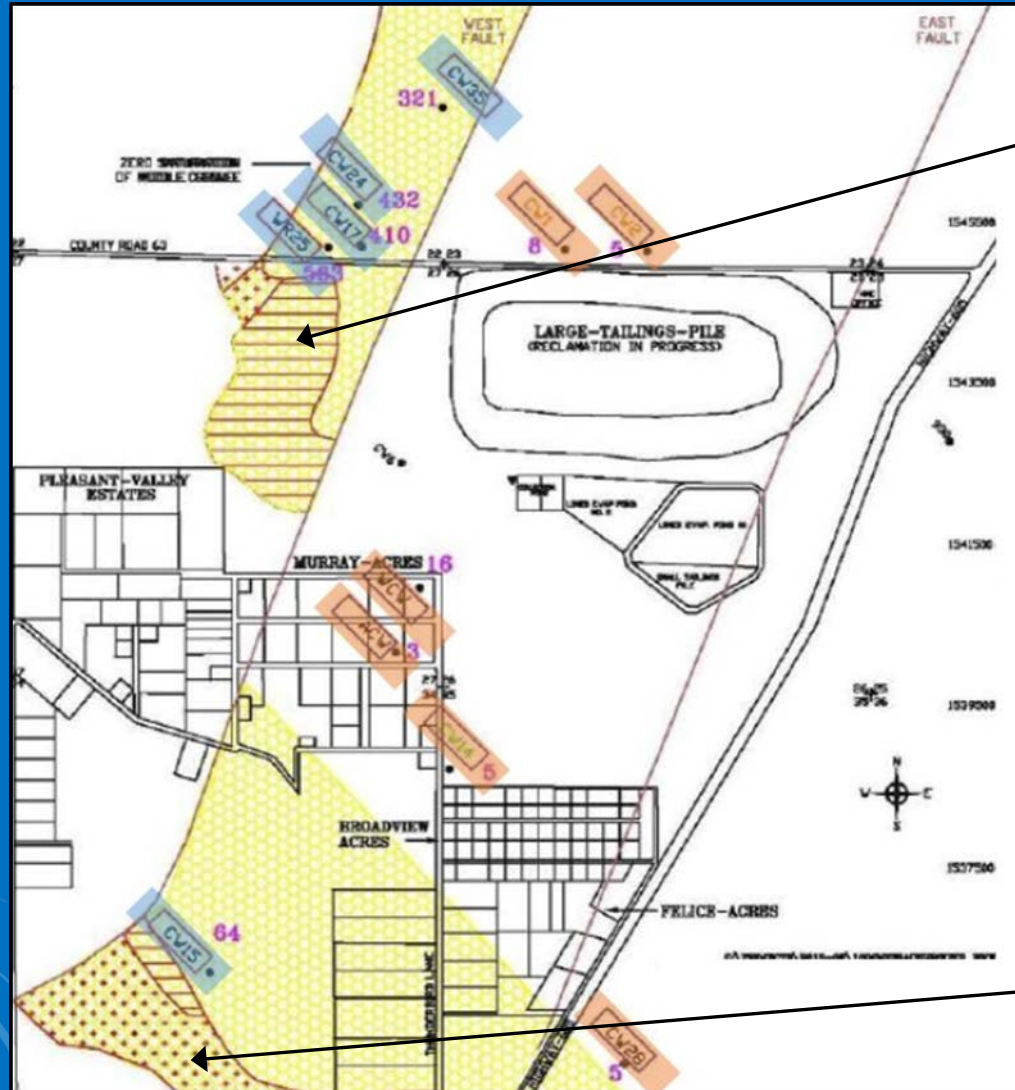
- Blue highlight: Upper Chinle Mixing Zone background wells
- CW9 & CW10 at depth under LTP; CW50 & CW52 at depth north of LTP – not affected by milling
- Orange highlight: Upper Chinle Non-Mixing Zone background wells

UPPER CHINLE MIXING ZONE: ALL WELLS



- Current GWPS for the Chinle Mixing Zone ~10x higher than proposed GWPS for Upper Chinle Mixing Zone (0.011 mg/L)
- Proposed GWPS for the Upper Chinle Non-Mixing Zone wells (farther to east) higher than Upper Chinle Mixing Zone – East Fault? Didn't move through mixing zone to get there.
- Extreme CW9 outlier eliminated (>6x higher than others)
- 68 data points with 68% below detection at 0.005 or 0.006 mg/L

MIDDLE CHINLE BACKGROUND WELL LOCATIONS

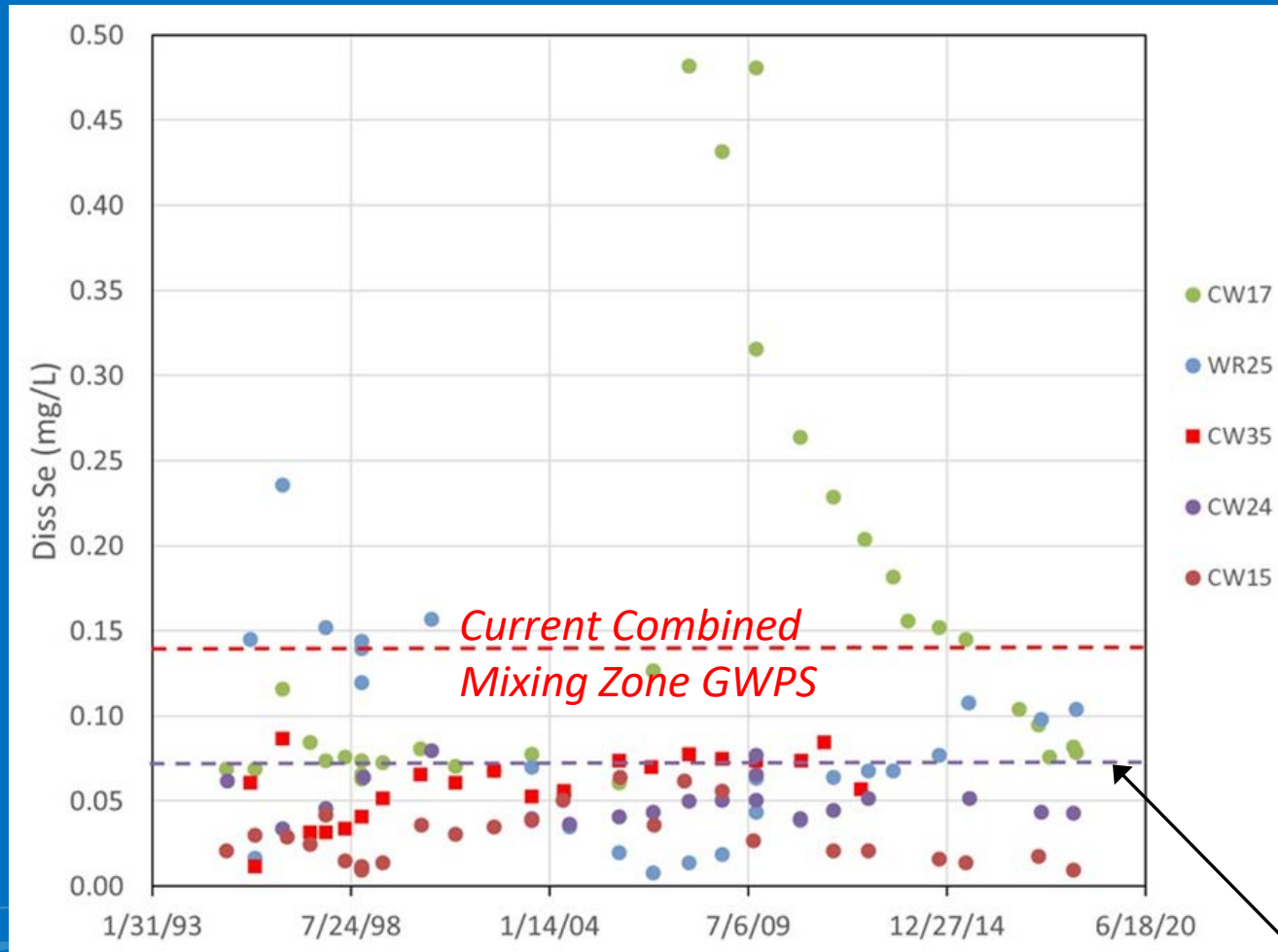


*Middle Chinle subcrop
below saturated alluvium*

- Blue: mixing zone; orange: non-mixing zone

*Middle Chinle subcrop below
unsaturated alluvium*

MIDDLE CHINLE MIXING ZONE: ALL WELLS



- CW17 eliminated – unexplained spikes
- All WR25 values eliminated – spikes from October 1995 to October 2000, and values from November 2007 to July 2015 consistently increasing
- 68 values remaining, none below detection; 95th percentile is 0.078 mg/L Se
- Proposed Middle Chinle Non-Mixing Zone GWPS lower – more work needed to distinguish impacted and true background values in the Middle Chinle Mixing Zone

*Proposed GWPS – Middle Chinle Mixing
(should be a little higher on graph)*

LOWER CHINLE WELLS

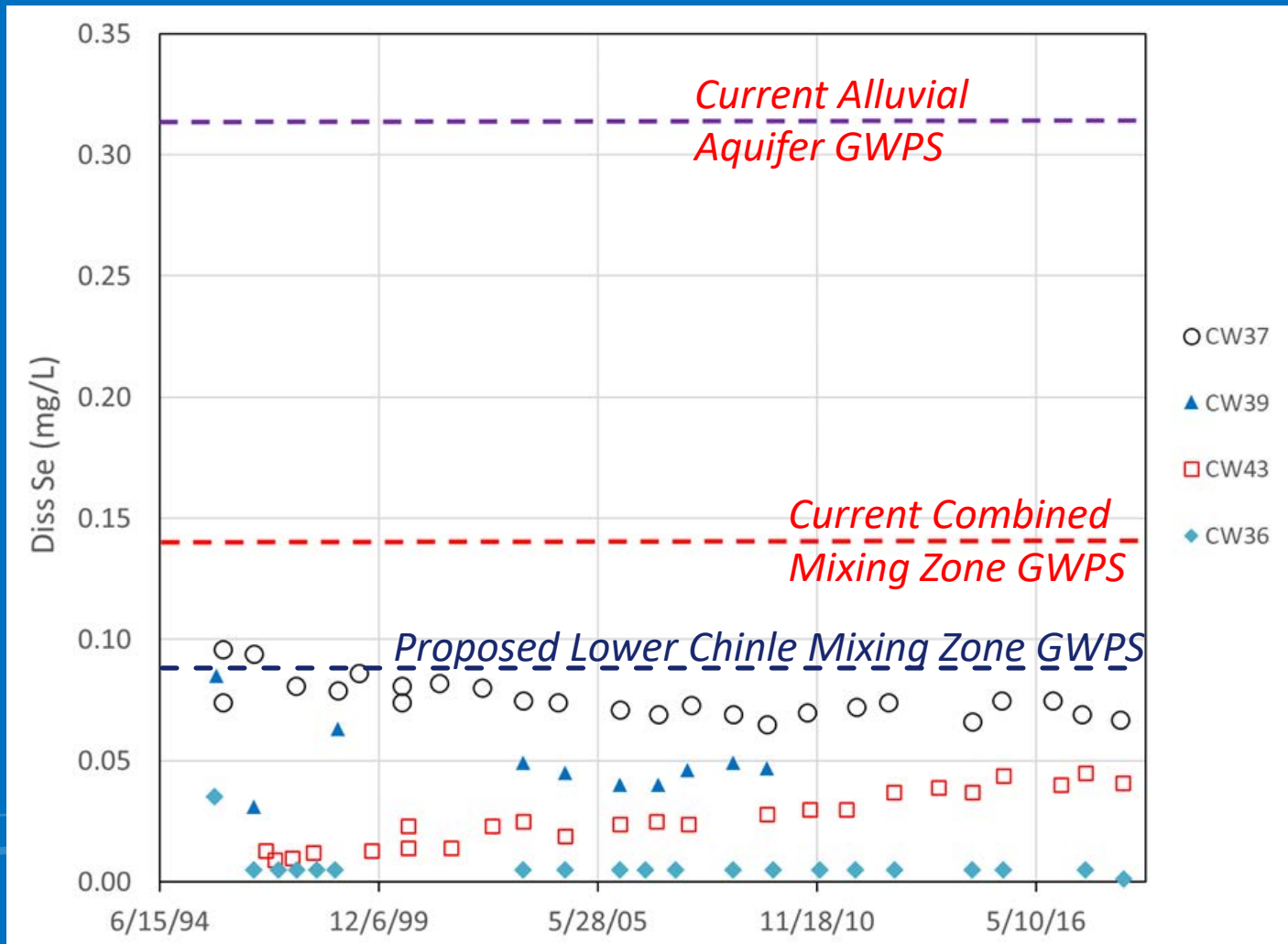
*Lower Chinle subcrop
below saturated alluvium*



*Lower Chinle subcrop
below saturated alluvium*

- Blue: Mixing zone; orange: non-mixing zone
- All are west of the West Fault
- CW39 and CS37 are south of Pleasant Valley Estates

LOWER CHINLE GWPS VALUES



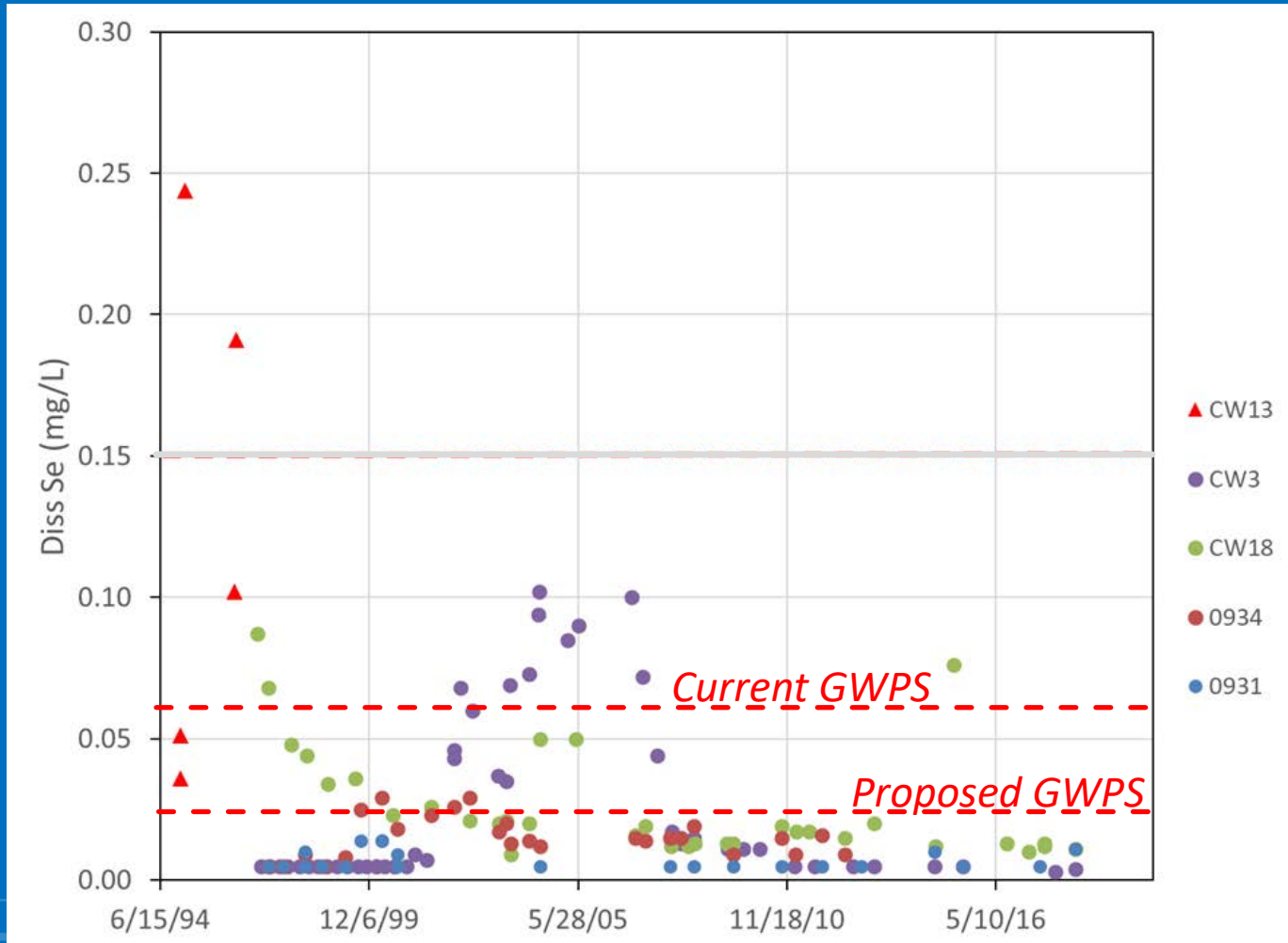
- CW37, CW39 – possible slight decrease over time
- CW43 values increasing over time
- Ongoing remediation efforts make it difficult to estimate a representative background concentration for selenium (or any other constituent)
- No data were excluded
- 79 data points, 24% below detection; 95th percentile is 0.082 mg/L
- Similar to Middle Chinle Mixing; much higher than Upper Chinle Mixing

CHINLE MIXING ZONE SUMMARY

	Chinle Mixing Zone: Combined	Chinle Mixing: Upper	Chinle Mixing: Middle	Chinle Mixing: Lower
Current GWPS	0.14	Not determined		
Proposed GWPS	0.079	0.011	0.078	0.082

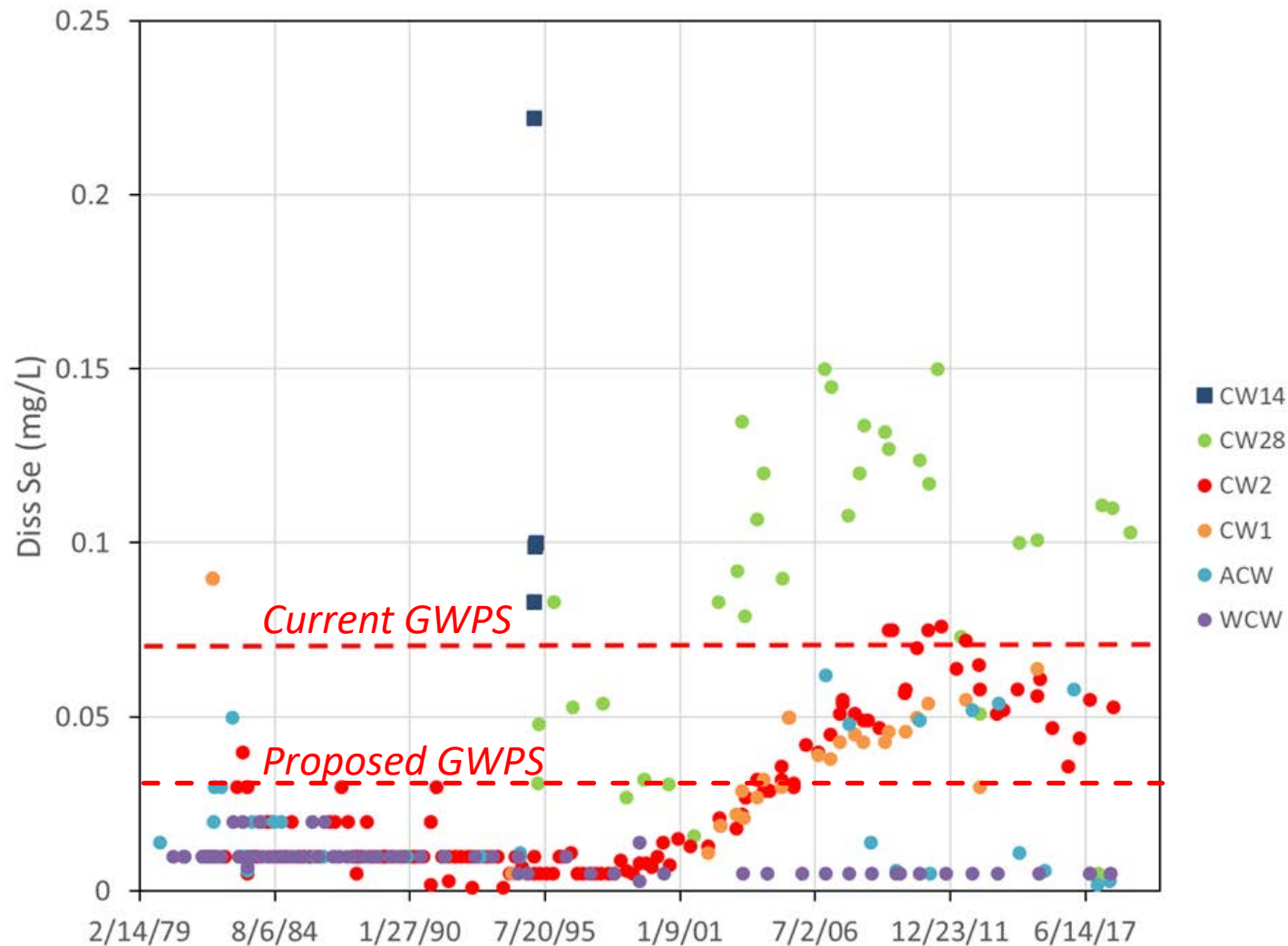
- Current GWPS for the Chinle Mixing Zone: 0.14 mg/L Se
- All Chinle Mixing Zone wells – this analysis
 - 215 results, 30% below detection
 - 95th percentile is 0.079 mg/L.
 - Middle and Lower Mixing Zones control proposed and current GWPS
- Upper Chinle Mixing Zone should be remediated separately

UPPER CHINLE NON-MIXING ZONE



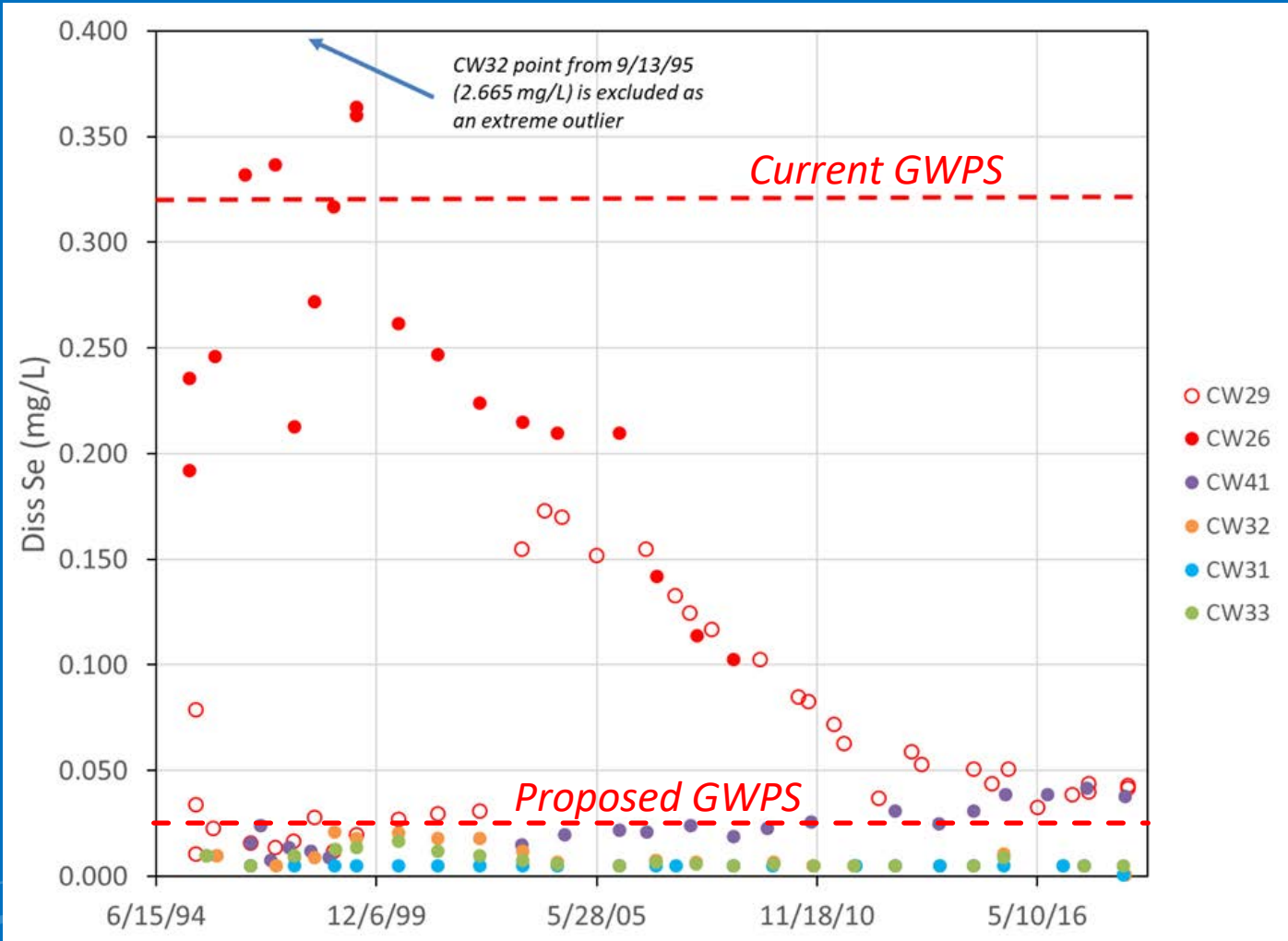
- CW13 is freshwater injection well – eliminated
- CW3 results from February 2002 onward excluded – 8-fold increase in concentration
- CW18 data excluded – high initially, may not have returned to background
- 48 remaining results, 71% below detection at 0.005 mg/L; 95th percentile is 0.024 mg/L Se.

MIDDLE CHINLE NON-MIXING ZONE



- CW14 eliminated – water injection wells SE of Murray Acres
- CW28 excluded – rose after first sampling
- CW1 and CW2 eliminated – pumped for remediation (collection wells), values rose in late 1990s and early spikes unexplained
- WCW OK – lower detection limits over time; early spikes in CW1, CW2, ACW unexplained - possibly intermittent releases from LTP
- Remediation lowering concentrations but not returned to background
- 108 remaining values, 79% below detection; 95th percentile is 0.027 mg/L Se.

LOWER CHINLE NON-MIXING ZONE



- CW26, CW29 excluded – high initially and may not have returned to background, CW29 remains elevated
- CW32 extreme outlier excluded
- CW41 rose at least by 2010 – excluded from 2010 onward
- 87 remaining data points, 53% below detection; 95th percentile is 0.022 mg/L selenium.

SUMMARY COMPARISON

	Alluvial	Chinle Mixing Zone: Combined	Chinle Mixing: Upper	Chinle Mixing: Middle	Chinle Mixing: Lower	Upper Chinle Non-Mixing Zone	Middle Chinle Non-Mixing Zone	Lower Chinle Non-Mixing Zone
Current GWPS	0.32	0.14	Not determined			0.06	0.07	0.32
Proposed GWPS	0.063	0.079	0.011	0.078	0.082	0.024	0.027	0.022

INFORMATION IN REPORT SUMMARY - EXAMPLE

Aquifer	Current GWPS ¹ (mg/L)	Proposed GWPS (mg/L)	Wells Included (time periods)	Wells excluded (see text for explanation)	Sample size	% Below Detection for Selected Data
Alluvial	0.32	0.063	P (1995-97), DD (1981-2014), ND (1983-98), 916 (1994-2005)	Q, R, P1, P2	131	9.2
Chinle Mixing Zone: Combined	0.14	0.079	See below	See below	215	30.2
Chinle Mixing: Upper	NA	0.011	CW9 (1987-2018), CW10 (1987-94), CW50 (2003-2017), CW52 (2003-2012)	CW9 (1 outlier)	68	68

RECOMMENDATIONS

- Re-evaluate the background water quality results for selenium and all other COCs, excluding data that reflects mining influence.
- The Upper Chinle Mixing Zone should be remediated to a lower (more protective) selenium concentration than the other two Chinle mixing zones.
- More work should be done to understand the relative transport rates of selenium and other COCs to help predict the future extent of contaminant plumes. Understanding transport rates will help focus remediation efforts on preventing the spread of existing and future contamination. Analysis of groundwater samples for selenium and uranium speciation will help predict transport rates.

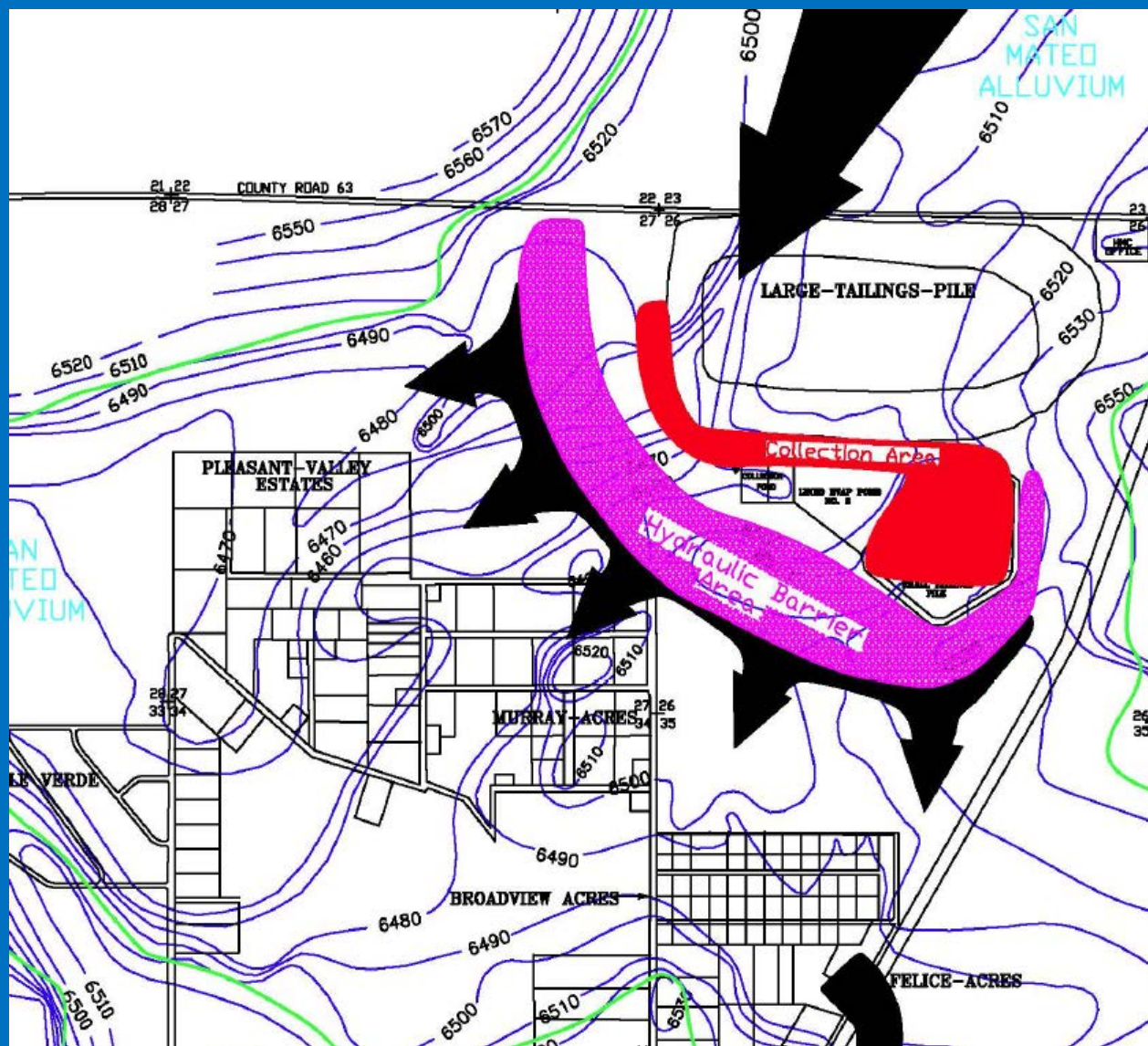
EXTRA SLIDES



IMPORTANT MISSING DATA AND INFORMATION

- ...there are large data gaps that need to be filled to fully characterize the ground water and the extent of impacts by mine discharge water recharge. There are areas larger than a square mile with no monitoring wells...Additional investigatory work is needed to fill these data gaps and refine the conceptual site ground-water model... (Weston Solutions, 2018, p. ES-6, ES-7)

ALLUVIAL FLOW AND HYDRAULIC BARRIER

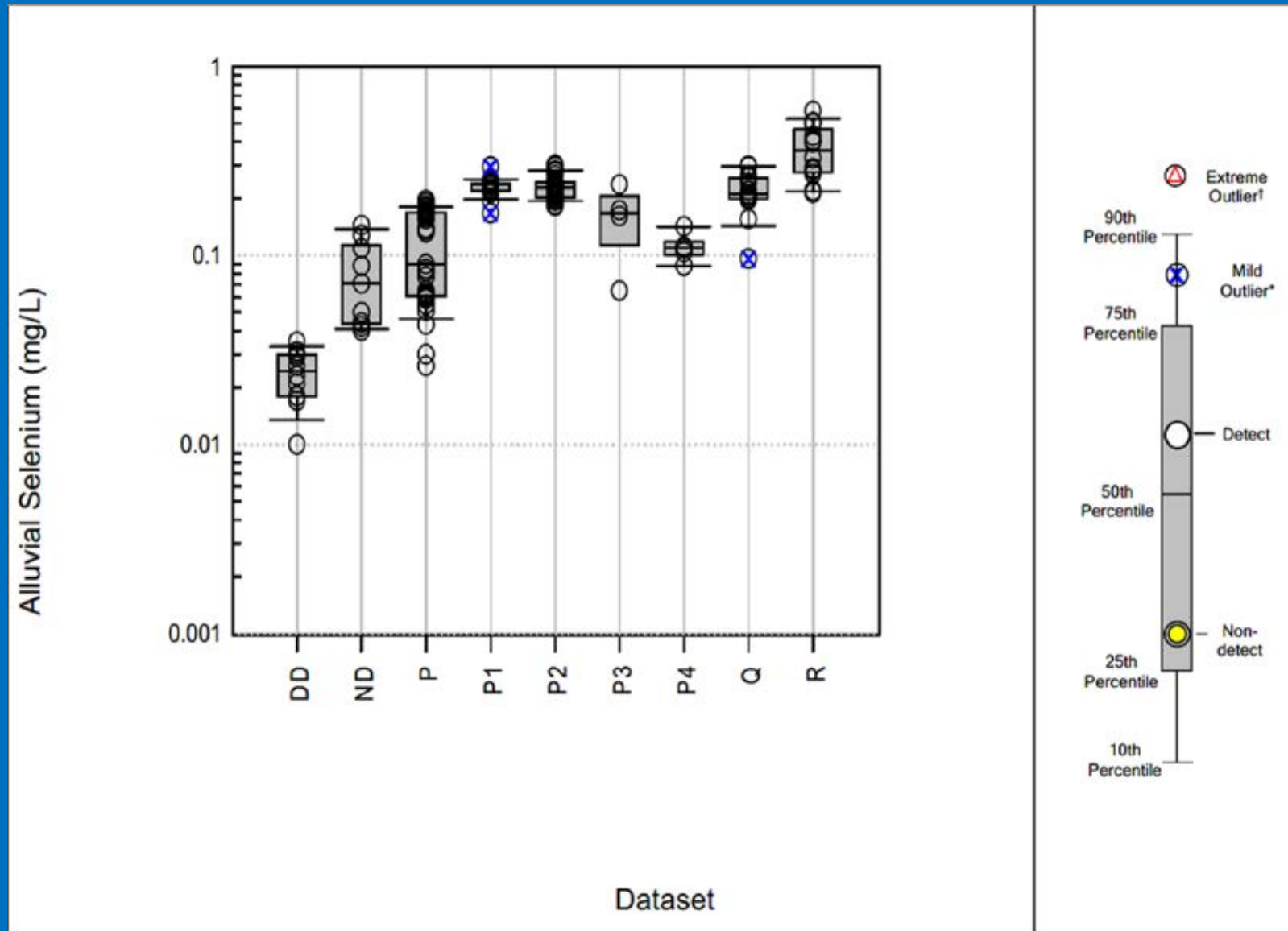


Source: Homestake, 2015; Figure 2-20.

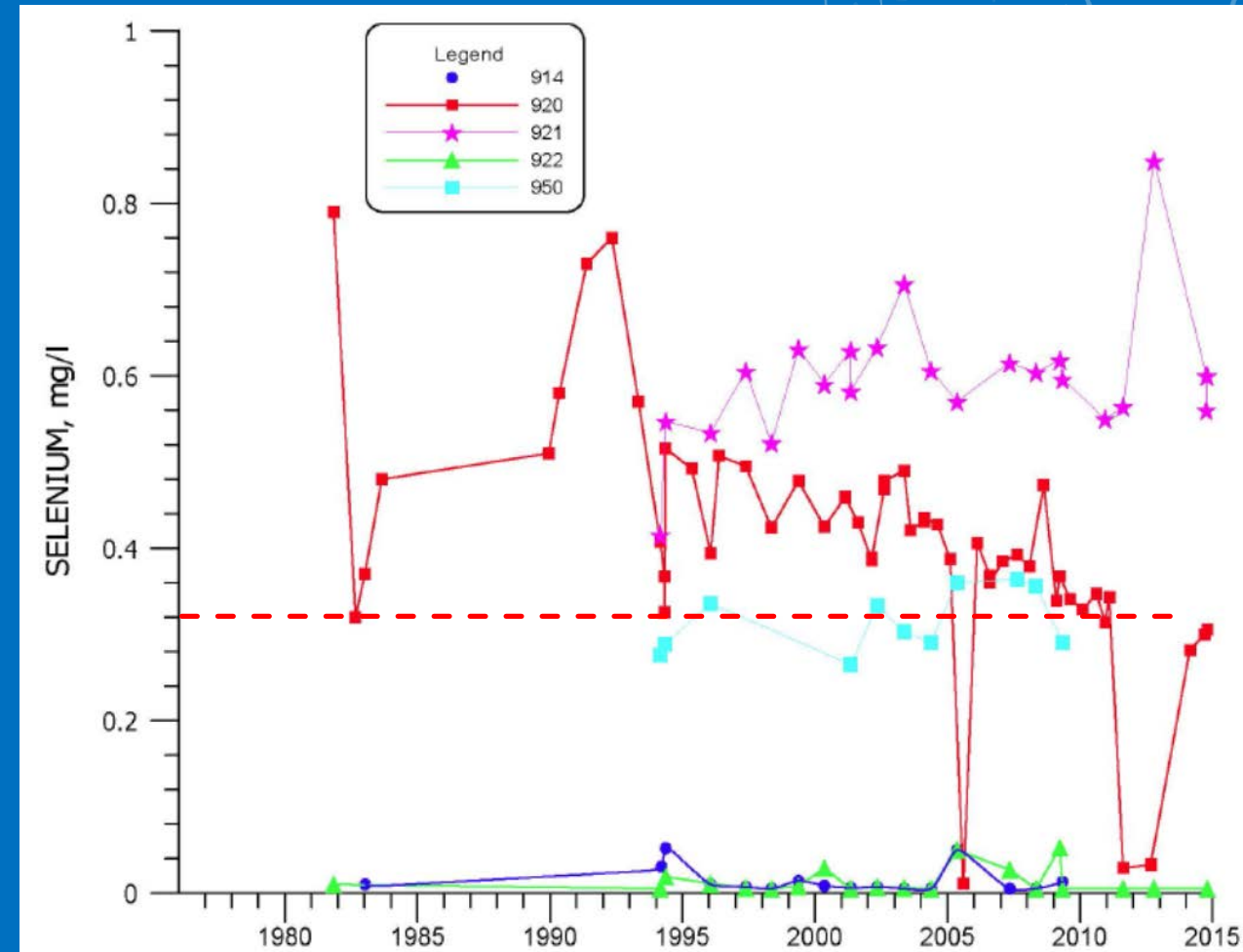
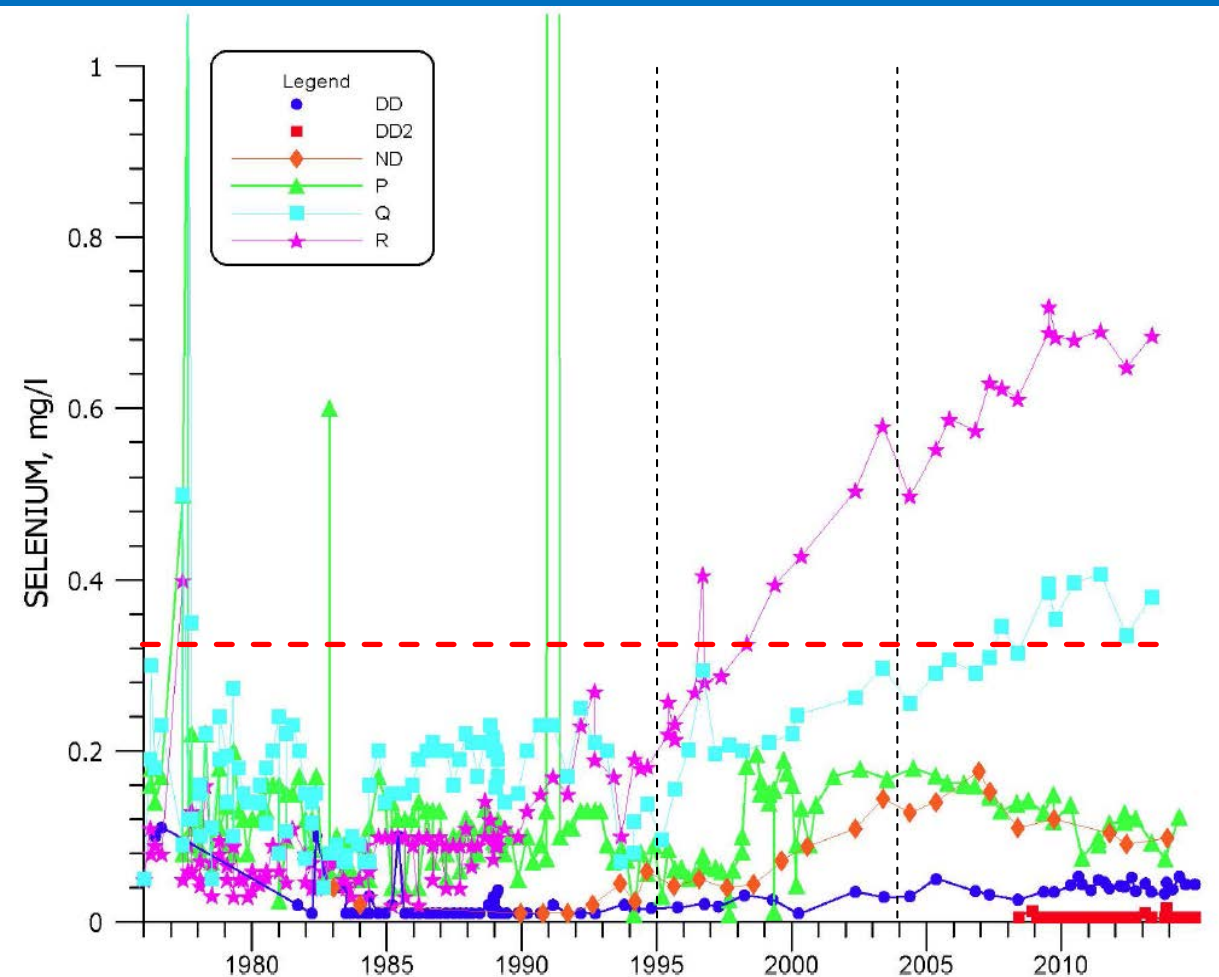
STANDARDS AND ADJUSTMENTS (MG/L UNLESS NOTED)

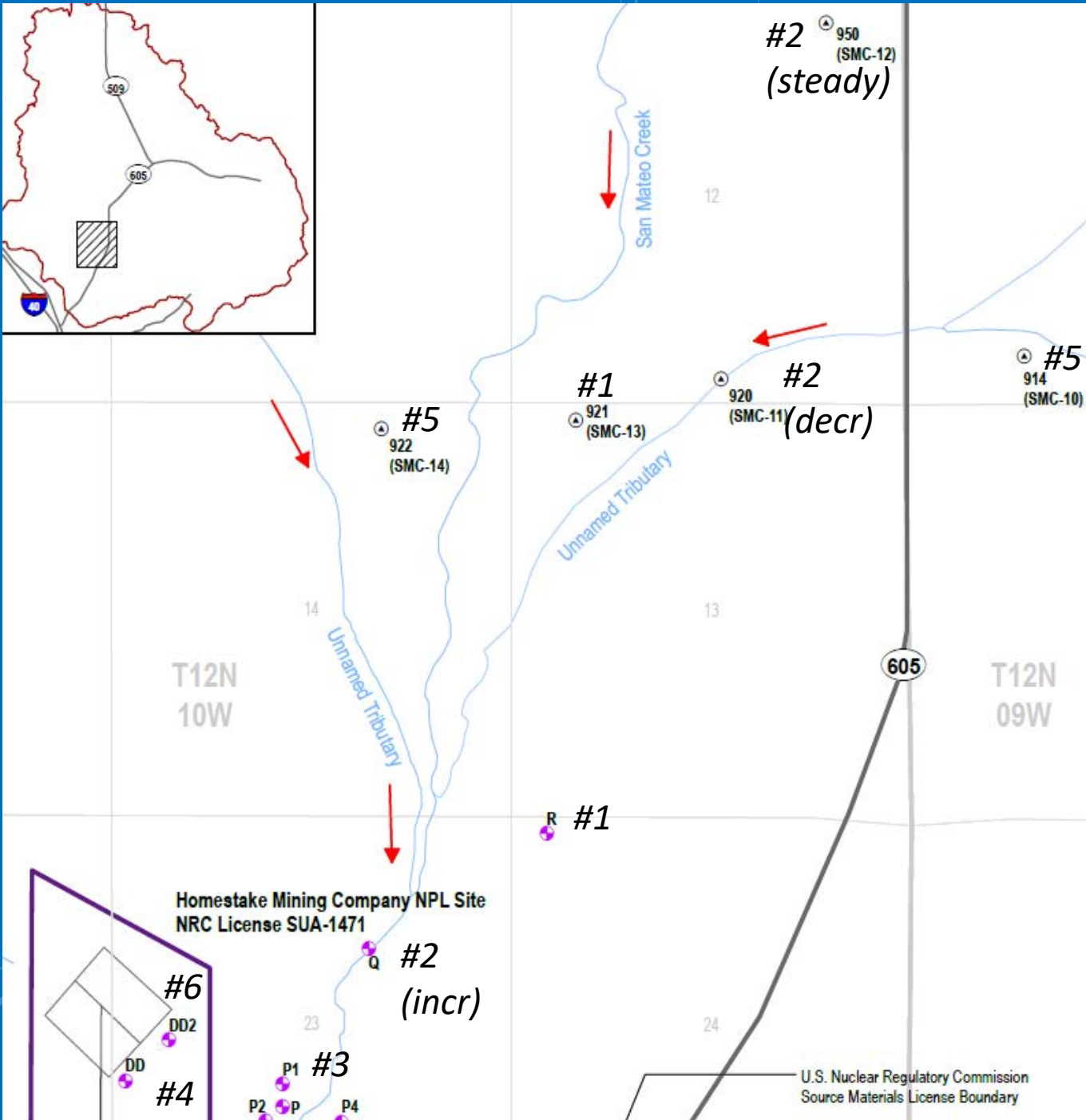
Parameter	NRC (GWPS)	NMWQCC (drinking water)	New Site Standards – Alluvial Aquifer	US EPA Safe Drinking Water Act
Uranium	0.04	0.030	0.160	0.03
Selenium	0.10	0.050	0.320	0.05
Molybdenum	0.03	1.0 (irrigation)	0.1	--
Vanadium	0.02	0.100 (irrigation)	0.02	--
Sulfate	--	600	1,500	250 (SMCL)
Chloride	--	--	250	250 (SMCL)
TDS	--	1,000	2,734	500 (SMCL)
Nitrate (as N)	--	10	12	10
Th-230 (pCi/L)	--	--	0.3	--
Ra-226+228 (pCi/L)	--	30	5	5

SELENIUM: ALLUVIAL WELLS



SELENIUM CONCENTRATIONS: BACKGROUND/ALLUVIAL WELLS





SELENIUM

- Approximate order of decreasing Se concentrations.
- DD and DD2 lower than other near upgradient wells and than some far upgradient wells.
- R and Q increasing trends; 920 decreasing trend.

ALLUVIAL GROUNDWATER ELEVATIONS/EXTENT

